Image 2825

PATENT
Attorney Docket No.: SAM-0266
Customer No.: 29344

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Ku, et al.
Serial No.: 09/992,980
Filing Date: November 6, 2001
Title: METHOD OF FORMING A METAL GATE ELECTRODE

Examiner: Lee, C.
Group Art Unit: 2825

CERTIFICATE OF MAILING UNDER 37 C.F.R. § 1.8

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Vanessa Marakas

Mail Stop Non-Fee Amendment
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P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL LETTER

Sir:

Enclosed herewith for filing in the above-identified patent application please find the following listed items:

1. Response to Office Action mailed on December 16, 2003; and
2. Return Postcard.

In connection with the foregoing matter, please charge any additional fees which may be due, or credit any overpayment, to Deposit Account Number 50-1798. A duplicate copy of this letter is provided for this purpose.

Respectfully submitted,

Date: March 15, 2004

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RESPONSE

Sir:

This is in response to the Office Action dated December 16, 2003, and is filed within the shortened statutory period of three months.

Claims 1, 3-4 and 9-12 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Tanabe, et al. (U.S. Patent number 6,197,702) in view of Rha (U.S. Patent number 6,284,634). In view of the following remarks, the rejections are respectfully traversed, and reconsideration of the rejections is requested.

In the applicants' invention, a nitrogen-containing gas is used during a selective oxidation process. The nitrogen combines with the metal in a metal gate electrode pattern to form metal nitride. As a result, the metal cannot react with oxygen in the process chamber, such that oxidation of the metal is minimized. The claims recite that the selective oxidation process includes introduction of hydrogen, oxygen and/or vapor H_2O along with a nitrogen-containing gas. As set forth in the claims, during the selective oxidation process, the nitrogen-containing gas combines with the metal layer to form a metal nitride. It is believed that the claims clearly

distinguish the applicants' invention and the cited Rha and Tanabe, et al. patents.

In Rha, a gate electrode includes a tungsten or tungsten silicide layer. Abnormal oxidation of the metal layer is inhibited by first annealing the structure in an environment that contains nitrogen. After the annealing is completed to form tungsten nitride 47 on the tungsten layer, the selective oxidation process is performed on the structure to relieve stress applied to the substrate. (See Rha at column 4 lines 8-9, column 4 lines 16-19, column 4 lines 22-24, and column 5 lines 21-29.) Clearly, Rha teaches a selective oxidation process performed separately from and after completion of an annealing step that creates tungsten nitride. That is, Rha does not teach or suggest the invention set forth in the applicants' claims in which creation of a metal nitride is performed simultaneously with a selective oxidation process by introduction of a nitrogen-containing gas into the chamber during the selective oxidation process.

In Tanabe, et al., nitrogen is contemplated only as an inert gas used to purge a process chamber before and after a light oxidation process (see Tanabe, et al. at column 16 lines 30-39, for example). Tanabe, et al. specifically teach that the nitrogen should not be in the chamber at the time oxidation is taking place so that an "undesirable nitriding reaction" is avoided (see column 16, line 33). In accordance with the explicit teachings of Tanabe, et al., the process furnace 100 is opened, and the nitrogen purge gas is introduced inside the chamber while the wafer is loaded into the chamber. The chamber is then closed, and gas exchange is carried out by the continuous introduction of the nitrogen purge gas. Next, hydrogen is introduced into the process chamber, while the nitrogen is discharged from the chamber, so that the undesirable nitriding reaction does not occur. Then, after the nitrogen is completely removed from the chamber, the oxygen and excess hydrogen are introduced into a reactor, and the water generated therefrom is introduced into the process chamber along with excess hydrogen to begin the oxidation process (see column 16, lines 16 through 44).

Thus, Tanabe, et al. explicitly teach that nitrogen is not present when an oxidation process is carried out using hydrogen and water vapor. In contrast, the applicants explicitly claim an oxidation process in which hydrogen, water vapor and a nitrogen containing gas are in the

process chamber at the same time. It is clear from this contrast alone that Tanabe, et al. do not teach or suggest the invention set forth in the claims.

In fact, Tanabe, et al. teach away from the claimed invention. The claims recite that the nitrogen in the chamber during the oxidation process serves to form metal nitride on the metal layer in a gate electrode pattern. Not only do Tanabe, et al. not teach or suggest this feature of the claimed invention, but they actually teach that a possible "nitriding reaction" is "undesirable" and is avoided by ensuring that all nitrogen is removed from the chamber before oxidation is carried out. The applicants respectfully submit that Tanabe, et al. could not more clearly and explicitly teach away from the present claims.

The applicants disagree with several of the Examiner's characterizations of the teachings of the Tanabe, et al. patent. For example, the Examiner states that Tanabe, et al. disclose performing a selective oxidation process in a chamber in a hydrogen-rich vapor and a nitrogen containing gas at column 14. The applicants have studied column 14 and the rest of the Tanabe, et al. patent, and can find no such teaching. Referring to column 14, the applicants find mechanical description in connection with Figures 9 through 11 of an oxidizing furnace 100 and a gas generator 140 having a reactor 141. The mechanical connections between gas reservoirs 144a, 144b and 144c and the reactor 141 are described. The only reference to processing parameters found by the applicants in the material referenced by the Examiner indicate that hydrogen and oxygen may be released from their respective reservoirs simultaneously such that they can react in the reactor 141. Figure 11 and the corresponding description refer to reactions between hydrogen H_2 and oxygen O_2. No reference to reactions involving nitrogen N_2 can be found. This is consistent with the rest of the Tanabe, et al. disclosure, though, since Tanabe, et al. consistently refer to nitrogen as a purge gas only, not to be involved in any kind of reaction during the oxidation process.

The Examiner states the Tanabe, et al. teaches nitridizing the gate electrode. In fact, Tanabe, et al. teach purging the chamber of nitrogen so that such nitridization does not occur. The Examiner states that this nitridization is called "light oxidation" by Tanabe, et al., and it is

carried out by introducing nitrogen into the chamber having a hydrogen-rich vapor. The applicants do not agree with this assessment of what is taught by Tanabe, et al. The applicants can find no suggestion whatsoever in Tanabe, et al. that they do not know the difference between oxidation and the "nitridization" referred to by the Examiner. Where Tanabe, et al. refer to nitride, they are clear about the potential for nitriding during oxidation, and they are explicit about their disclosure that such nitriding is to be avoided. Furthermore, they do not teach introducing nitrogen into the chamber having a hydrogen-rich vapor. In fact, they teach the very opposite. As noted above, Tanabe, et al. explicitly teach ensuring that all nitrogen is removed from the chamber before hydrogen-rich vapor is introduced.

For these and other reasons, the Tanabe, et al. patent fails to teach or suggest the invention set forth in the claims. Specifically, Tanabe, et al., like Rha, fail to teach or suggest introducing a nitrogen-containing gas into a chamber during an oxidation process to form a metal nitride during oxidation. Since neither of the references teach this feature set forth in the claims, there is no combination of the references which would result in such teaching or suggestion.

Since neither of the cited references, taken alone or in combination, teaches or suggests the invention set forth in the claims, it is believed that the claims are allowable over the references. Therefore, reconsideration of the rejections of the claims under 345 U.S.C. § 103(a) based on Tanabe, et al. and Rha is respectfully requested.

In view of the foregoing remarks, it is believed that all claims pending in the application are in condition for allowance, and such allowance is respectfully solicited. If a telephone conference will expedite prosecution of the application, the Examiner is invited to telephone the undersigned.

Respectfully submitted,

Date: March 15, 2004

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